

April 1989

STRATEGIC DEFENSE INITIATIVE PROGRAM

Zenith Star Space-Based Chemical Laser Experiment





United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-223094

April 14, 1989

The Honorable J. Bennett Johnston
United States Senate

Dear Senator Johnston:

This report responds to your request that we review selected aspects of chemical laser research managed by the Strategic Defense Initiative Organization.

As requested, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time we will send copies to the chairmen of appropriate committees; the Secretaries of Defense and the Air Force; the Directors, Strategic Defense Initiative Organization and Office of Management and Budget; and other interested parties.

GAO staff members who made major contributions to this report are listed in appendix II.

Sincerely yours,

A handwritten signature in cursive script that reads 'Harry R. Finley'.

Harry R. Finley
Director, Air Force Issues

Executive Summary

Purpose

Senator J. Bennett Johnston and former Senator William Proxmire asked GAO to examine selected aspects of the Strategic Defense Initiative Organization's (SDIO) Space-Based Chemical Laser Research Program. Specifically, they asked GAO to review (1) the progress and changes in space-based chemical laser research, (2) whether apparent changes in priority within the directed energy program had resulted in the emphasis of space-based chemical laser technologies to the detriment of more promising directed energy concepts, and (3) the actions taken by the Department of Defense's Compliance Review Group and SDIO to determine the compliance of proposed testing with applicable Anti-Ballistic Missile Treaty provisions.

Background

The Strategic Defense Initiative Program underwent a change in 1987 when the Department of Defense approved a phased deployment approach for the Strategic Defense System, a ballistic missile defense system. The plan provides for the initial deployment of a phase I system, followed by several follow-on deployment phases as the Soviet threat evolves. For this report, GAO divided the follow-on phases into an early follow-on phase (the first follow-on phase after phase I) and a late follow-on phase.

SDIO is developing space-based chemical lasers, ground-based free-electron lasers, and neutral particle beam generators for possible deployment during the follow-on phases to cope with potential changes in the Soviet ballistic missile threat.

The space-based chemical laser is the leading candidate for deployment during the early follow-on phase because it is the most mature laser technology. It would be used to destroy ballistic missile boosters and post-boost vehicles, supplementing the space-based interceptor rockets deployed during phase I. It would also assist in discriminating warheads from decoys in the midcourse phase of ballistic missile flight.

In 1984 SDIO took over development of the technology needed to build the major components for a space-based chemical laser—the Alpha laser; the beam control system; the large mirror; and the acquisition, tracking, and pointing system.

Results in Brief

A possible early follow-on deployment role for space-based chemical lasers was added to the program in 1987. Progress in developing the technologies for a space-based chemical laser is about 1 to 2 years behind the schedule SDIO estimated in 1984. However, to demonstrate feasibility in time to deploy during the early follow-on phase, SDIO, in January 1987, initiated the Zenith Star Program to test a space-based chemical laser in 1990—about 4 years earlier than previously planned. However, as of March 1989, the launch date had slipped from 1990 to the mid-1990s.

SDIO officials said that the space-based chemical laser program has not been emphasized to the detriment of other laser technologies. SDIO officials said that research priorities for space-based chemical lasers and ground-based free-electron lasers for deployment during the late follow-on phase remain unchanged. Both are still being developed as candidates for this role.

In September 1988 the Department of Defense's Compliance Review Group determined that SDIO's proposed Zenith Star experiment design complied with the traditional, or restrictive, interpretation of the Anti-Ballistic Missile Treaty.

GAO's Analysis

Status of Technologies

When SDIO was created in 1984, it assumed responsibility, from the Defense Advanced Research Projects Agency, for the ongoing research program called the Triad Program, which was aimed at developing the major components needed for a space-based chemical laser. These component technology projects provide the building blocks for the Zenith Star space experiment.

Since 1984 these technology projects have fallen 1 to 2 years behind SDIO's original schedule. Some of the planned research work has been eliminated or significantly cut back. The laser has been built, but it has not yet produced a laser beam. Beam control technology work was significantly reduced from SDIO's original plans. The date for an initial acquisition, tracking, and pointing space experiment has slipped from 1988 to 1990. The large primary mirror has been built but needs some modifications to operate with the high-powered laser in space, according to SDIO.

Priorities

SDIO officials said that research priorities remain unchanged for space-based chemical lasers and ground-based free-electron lasers for potential deployment during a late follow-on phase. A possible early follow-on deployment role for space-based chemical lasers was added to the program in 1987; however, SDIO officials said that the space-based chemical laser program has not been emphasized to the detriment of other laser technologies.

In developing phased deployment plans, SDIO's Director said that SDIO needed to demonstrate a capability to deal with responsive threats, or countermeasures, that the Soviets were likely to take in response to a phase I deployment of U.S. space-based interceptor rockets. SDIO concluded that a directed energy weapon may be needed to counter possible Soviet responses to a phase I deployment. Only space-based chemical laser technology was judged mature enough to demonstrate a directed energy weapon in time to meet the originally proposed decision timetable for phase I.

SDIO's Director said that SDIO's strategy is to use the Zenith Star space-based chemical laser experiment to demonstrate to the Soviets that the United States has the potential to block certain responses they might take to phase I deployment. The objective is to deter the Soviets from building and deploying options they may have to counter a phase I deployment. If the Soviets were deterred, the United States might not need to deploy space-based chemical laser weapons.

Accordingly, SDIO proposed testing a laser in space 4 years earlier than the originally planned 1994 date. However, as of March 1989, the launch date for the Zenith Star test had slipped from the proposed accelerated date of 1990 to the mid-1990s.

Treaty Compliance

Initial contractor design studies for Zenith Star from January through June 1987 were not restricted to designing tests that complied with the Anti-Ballistic Missile Treaty. SDIO officials said that unrestricted design feasibility studies are generally done to understand the capabilities of the technology. In early June 1987, the studies were redirected to include test designs that would comply with the traditional, or restrictive, Treaty interpretation before the designs were submitted for formal Treaty compliance review by the Department of Defense.

Proposed designs were submitted to the Department of Defense's Compliance Review Group beginning in June 1987. In September 1988 the Department of Defense determined that the Zenith Star experiment complied with the restrictive interpretation of the Anti-Ballistic Missile Treaty.

Agency Comments

The Department of Defense generally concurred with the findings in this report (see app. I). GAO has included clarification and additional information provided by the Department of Defense where appropriate.

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Abbreviations

ABM	Anti-Ballistic Missile
ATP	acquisition, tracking, and pointing
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
GAO	General Accounting Office
LISE	Laser Integrated Space Experiment
SBCL	space-based chemical laser
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization

Introduction

The Strategic Defense Initiative (SDI) Program underwent a change in 1987 when the Department of Defense (DOD) approved a phased deployment approach for the Strategic Defense System, a ballistic missile defense system. The new plan provides for the deployment of a phase I system, to be followed by several follow-on deployment phases as the Soviet threat evolves. For this report, we divided the follow-on phases into an early follow-on phase (the first follow-on phase after phase I) and a late follow-on phase.

The Strategic Defense Initiative Organization (SDIO) is developing space-based chemical lasers (SBCL), ground-based free-electron lasers, and neutral particle beam generators for possible deployment during the follow-on phases to cope with potential changes in the Soviet ballistic missile threat after the deployment of phase I.

Perspective on Space-Based Chemical Laser Research

When SDIO was created in 1984, it assumed responsibility for the ongoing SBCL research program from the Defense Advanced Research Projects Agency (DARPA). DARPA had been developing the major components needed for an SBCL in its Triad Program, which included projects to develop

- the Alpha laser device to generate the laser beam;
- the Large Optics Demonstration Experiment to control and direct the laser beam;
- a large mirror to direct the laser beam at the target; and
- the Talon Gold Experiments for target acquisition, target tracking, and beam pointing (called acquisition, tracking, and pointing (ATP)).

These component technology projects provide the building blocks for the proposed Zenith Star space experiment.

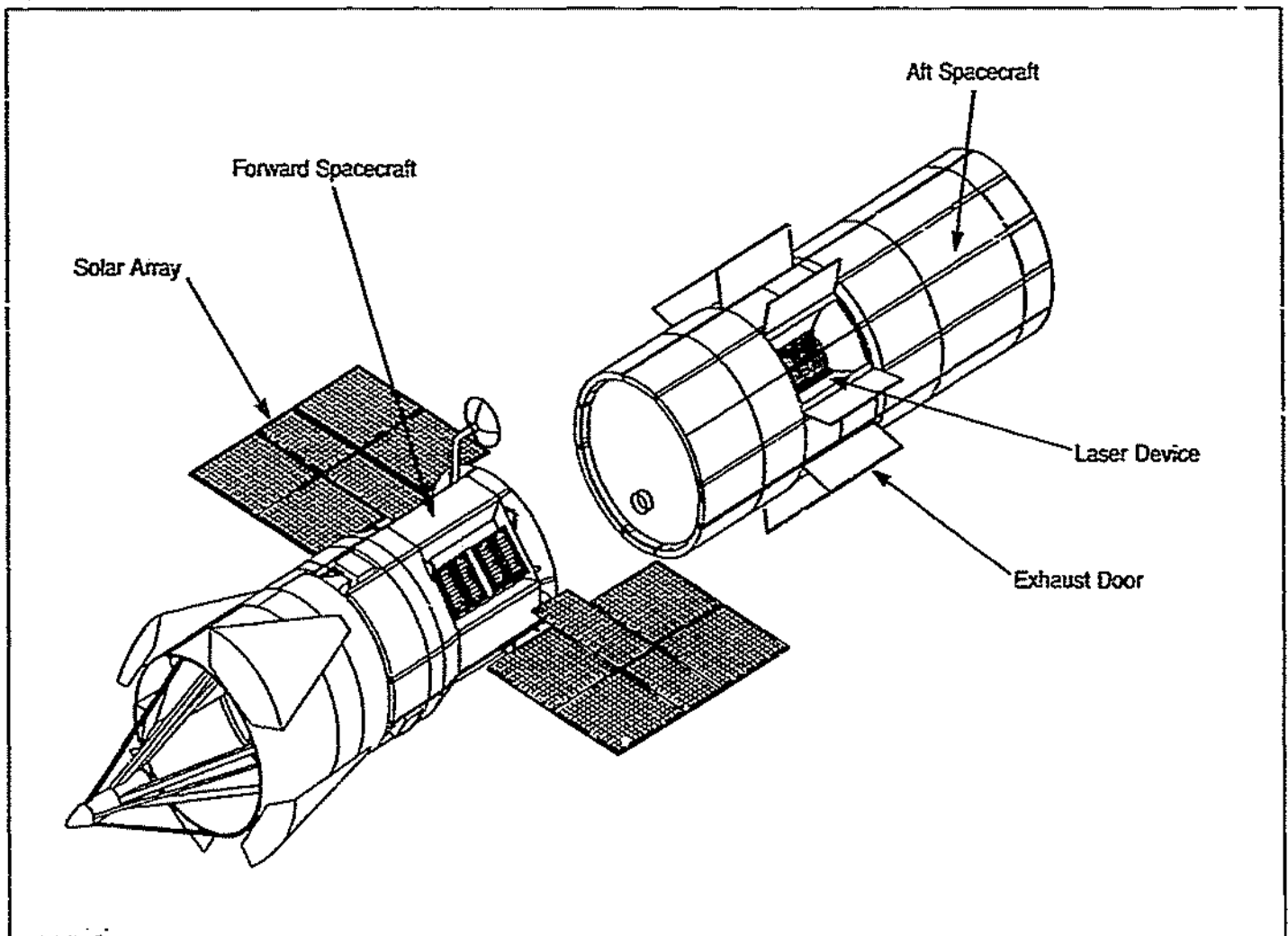
In 1984 SDIO developed a Directed Energy Weapon Program Plan, which defined the research and demonstrations to be carried out for the Triad components. Completion of SBCL research in the 1984 Plan was to support a decision in 1990 on whether to begin developing a space experiment that would be launched in 1994.

Zenith Star Program

To demonstrate SBCL technology in a time frame consistent with phased deployment planning, SDIO, in January 1987, initiated the Zenith Star

Program. The program was begun primarily to demonstrate the feasibility of operating an SBCL in space. The Zenith Star space experiment consists of two spacecraft (see fig. 1.1) that will be separately launched and joined together in space. The aft spacecraft contains the high-powered laser. The forward spacecraft contains the beam control system, the science module, and the ATP system. After a few months of experiments, the high-powered laser spacecraft is to be separated from the forward spacecraft and safely dropped from orbit into the atmosphere, while the forward spacecraft will remain in orbit for about 1 year.

Figure 1.1: Zenith Star Forward and Aft Spacecraft



The high-powered laser in the aft spacecraft will be operated to study high-energy beam behavior and control. After the completion of these

experiments over a few months, the aft spacecraft will be separated from the forward spacecraft.

After separation from the aft spacecraft, the science module in the forward spacecraft will be used for about 1 year to do ATP and other experiments. One set of ATP experiments will use solid and liquid rockets and other targets of opportunity—such as Delta, Titan, and Minuteman missiles—to demonstrate the ATP system. The science module will also collect data on objects and backgrounds of interest with the infrared, ultraviolet, and visible light sensors.

Phased Deployment

Phased deployment of the Strategic Defense System involves deploying the full, population protection defensive system in successive phases. By 1987 DOD and SDIO had adopted phased deployment as the only practical way to proceed. The Joint Chiefs of Staff also believed that a “thoroughly effective defense” could only be achieved in steps, and they stressed that an initial deployment should not be considered a complete ballistic missile defense system.

SDIO’s deployment plans have an unspecified number of phases, each adding a defensive weapon or other enhancement to the prior phases. After phase I, the phases are generally referred to as “follow-ons.” Each Strategic Defense System deployment phase has three objectives: to perform a meaningful military mission, to compel changes (operational or technical) in the Soviet ballistic missile force, and to lay the foundation for the improved follow-on phases. SDIO currently projects that phase I capability might be achieved in the late 1990s and that an early follow-on might occur in the early 2000s.

The Strategic Defense System elements for phase I deployment include sensors in high-earth orbit to detect and track offensive missiles, space-based interceptor rockets to attack boosters and post-boost vehicles, midcourse sensors to discriminate and track warhead-carrying reentry vehicles, ground-based interceptors to attack the reentry vehicles, and a ground command center.

SDIO plans also include preliminary proposals for the deployment of directed energy weapons during the follow-on phases. The SBCL is the leading candidate for deployment during the early follow-on phase because it is the most mature laser technology. The SBCL would be used

to destroy ballistic missile boosters and post-boost vehicles, supplementing the space-based interceptor rockets deployed during phase I. It would also provide midcourse discrimination capabilities.

Objectives, Scope, and Methodology

Senator J. Bennett Johnston and former Senator William Proxmire asked us to examine SDIO's SBCL program. They expressed concern over whether changes in priority within the directed energy program put unwarranted emphasis on SBCL technology, to the possible detriment of more promising directed energy concepts. They were also concerned that the proposed Zenith Star space experiment could violate the 1972 Anti-Ballistic Missile (ABM) Treaty. Consequently, we were asked to

- review the progress and changes in SBCL research,
- examine the changes in priority of the SBCL and ground-based free-electron laser,
- examine whether SBCL research has been directed toward a test that would violate the traditional interpretation of the ABM Treaty, and
- provide information on the relationship between the Zenith Star experiment and the Laser Integrated Space Experiment described in the May 19, 1987, DOD report to the Congress on the ABM Treaty.

We examined program documents and interviewed program participants at SDIO; the Office of the Assistant Deputy Director for Strategy, Arms Control, and Compliance; and the Army Strategic Defense Command, all in Washington, D.C.; Martin Marietta Denver Aerospace (the Zenith Star integration contractor), Denver, Colorado; the Lockheed Missile and Space Company, Inc., Sunnyvale, California; TRW, Incorporated, Redondo Beach, California; the Rome Air Development Center, Griffiss Air Force Base, New York; and the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico. As agreed with the requesters, we did not attempt to interpret ABM Treaty requirements as they apply to SBCL research but reviewed actions taken by DOD's Compliance Review Group and SDIO officials to determine the status of SDIO's compliance with applicable Treaty provisions.

We performed our work from January 1988 to March 1989 in accordance with generally accepted government auditing standards.

Status of Space-Based Chemical Laser Research

Since 1984 the SBCL experiment's component technologies have fallen 1 to 2 years behind SDIO's initial schedule, baselined in its 1984 Directed Energy Weapon Program Plan. Some of the planned research work has been eliminated or significantly cut back. SDIO attributes the slippage and reductions to unanticipated technical problems and to funding that was less than requested.

The laser has been built, but it had not yet produced a laser beam as of February 1989. Beam control technology work was significantly reduced from SDIO's original plans. The laser's large primary mirror has been built, although it is a year and a half behind its original schedule and will require modification for the Zenith Star experiment. The original ATP space experiment was canceled and replaced by the Starlab experiment, which is now scheduled for late 1990.

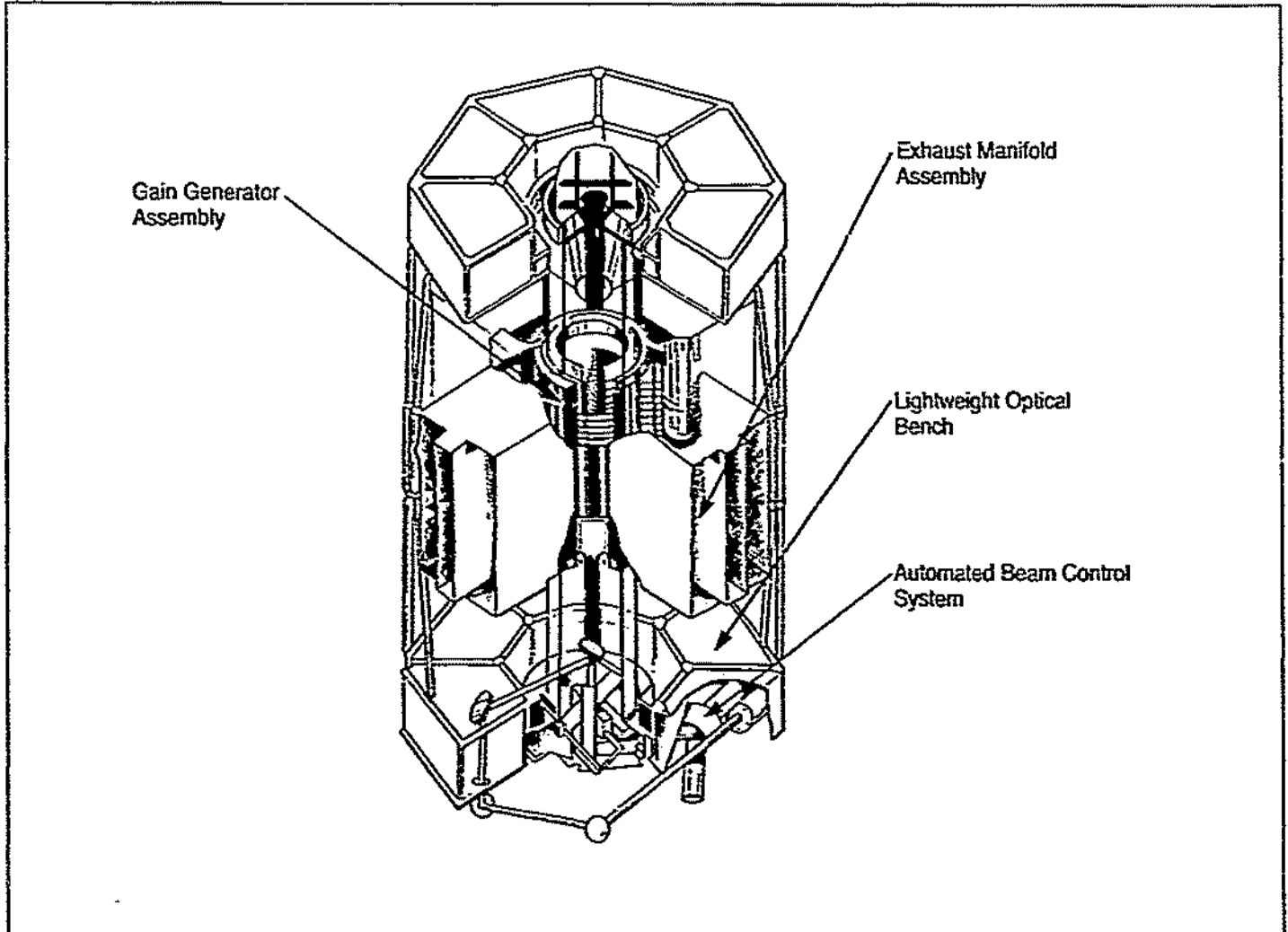
Alpha Laser

SDIO and the contractor for the Alpha chemical laser device are working toward producing a high-energy laser beam at the ground test facility in Capistrano, California, in late March 1989. As of February 1989, the laser parts had been built and installed, and component and integrated testing were underway, but the laser had not produced a beam. After it is successfully tested, the laser will be modified for operation in space, reinstalled in the ground-test facility with the Zenith Star beam control system, and tested again prior to use in the space experiment. Figure 2.1 depicts the laser.

The laser program has experienced delays, modifications, and cost overruns. The ground testing has slipped more than 1 year, a slippage that program officials attribute to funding reductions, technical difficulties, and a fire at the ground-test facility. SDIO and the contractor said that funding allocations had forced some changes in the research program. The ground test was to have been completed at the end of 1987. Now the contractor expects to complete initial testing in mid-1989, more than a 1-year slip. Because of budget constraints, the laser was built to be operated on the ground. Modification of existing hardware is therefore necessary to make the laser operable in space. Also, a system to contain the fuel for the space operation must be built.

The contractor originally estimated that the laser program would cost about \$150 million. As of March 1989, this estimate had increased by \$53 million.

Figure 2.1: Illustration of the Alpha Laser

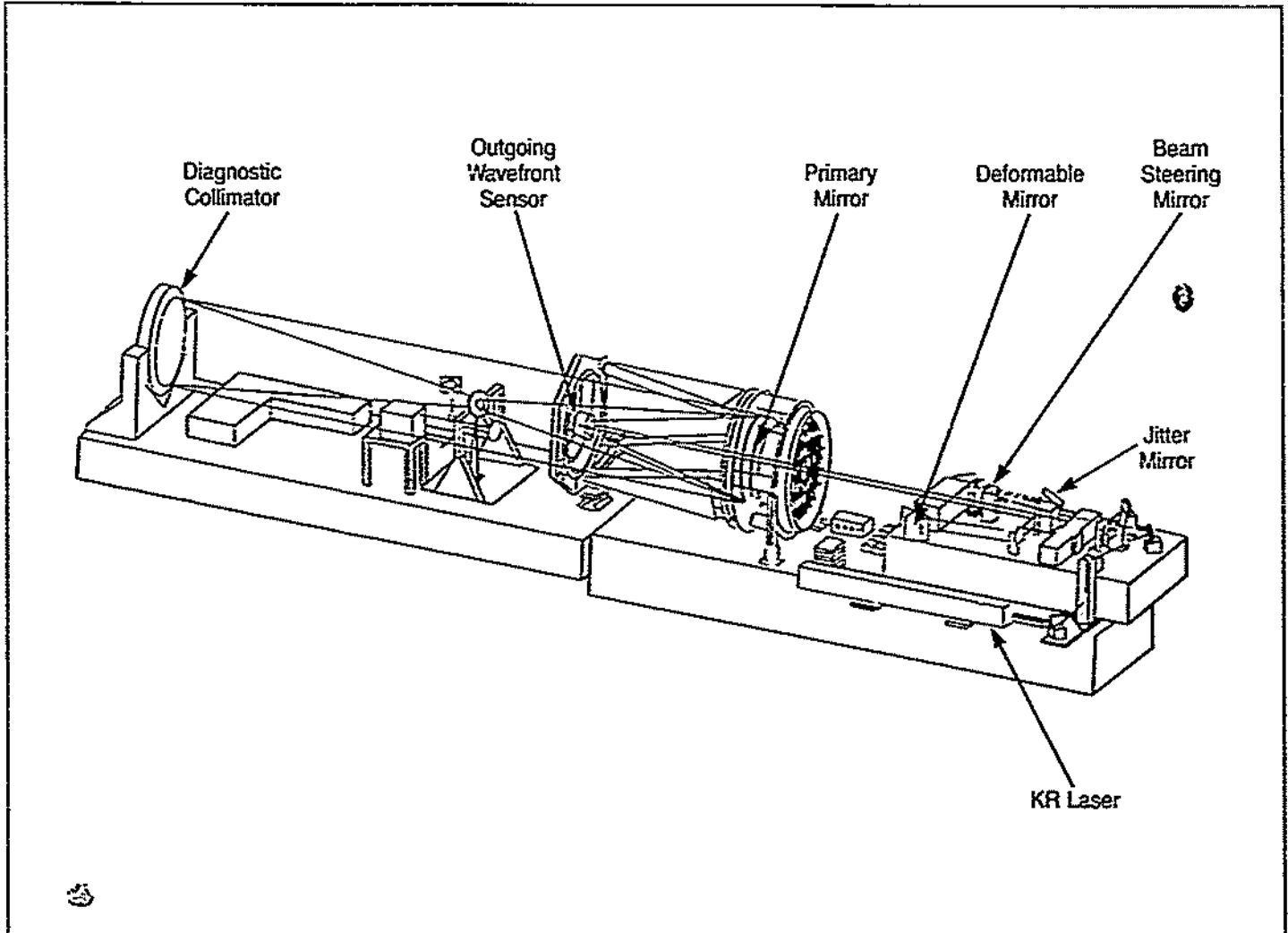


Beam Control

SDIO's objective for the Large Optics Demonstration Experiment beam control program was to demonstrate a system that would sample the beam and correct distortions to produce a high-quality beam. SDIO used a laboratory bench system, called a "brassboard" (see fig. 2.2), for testing the electronic and optical components, controls, and software. Program officials said the research objectives were changed and some of the planned experiments dropped because of technical problems and funding constraints.

SDIO reported that it has successfully demonstrated the ability to correct imperfections in a high-power beam by using the low-power brassboard

Figure 2.2: Illustration of the Beam Control Brassboard



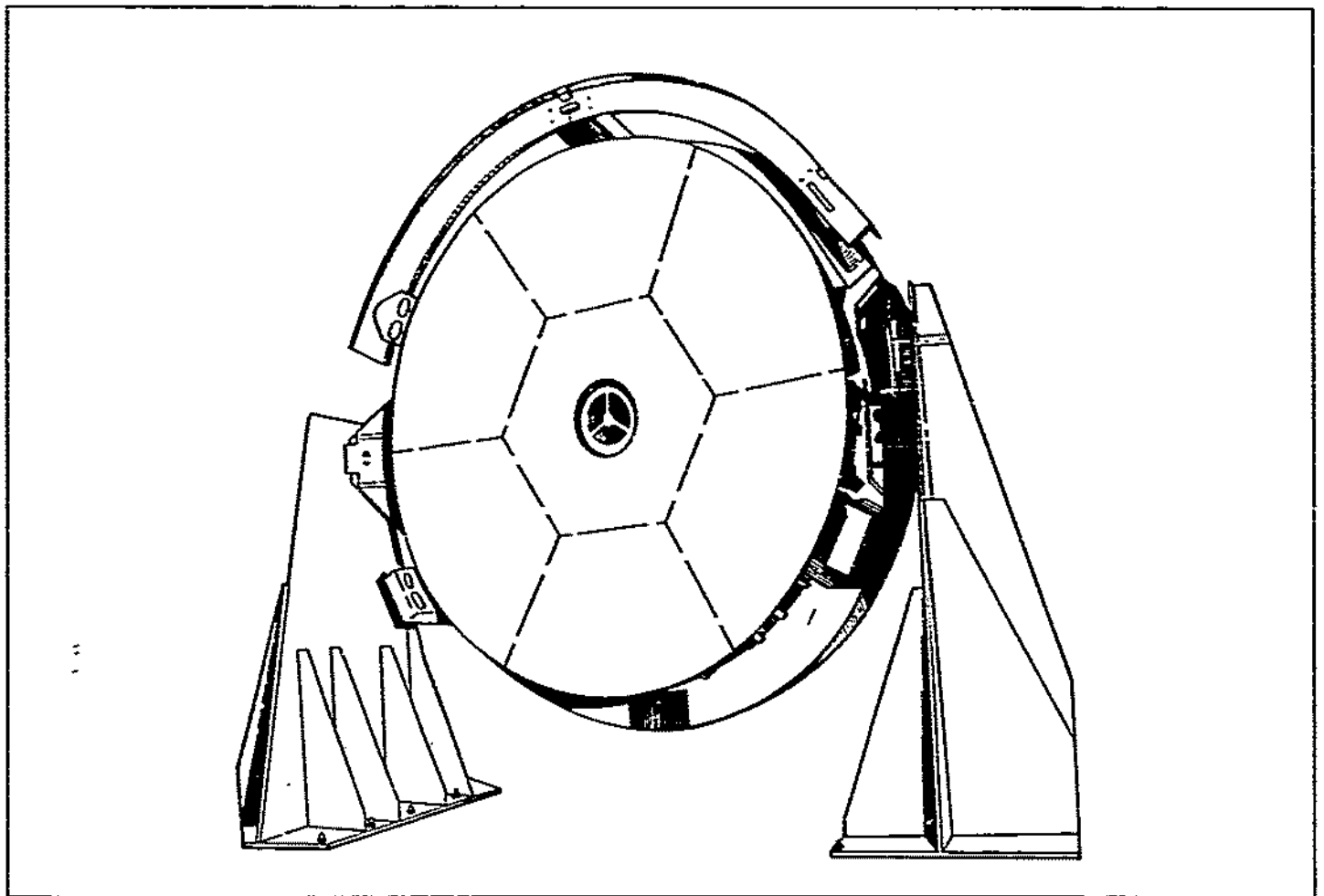
device and analytic projections. The high-power beam control system for Zenith Star, which will use some of the brassboard technology, has yet to be built. SDIO's program was estimated in 1984 to cost about \$70 million for fiscal years 1984 through 1988. However, work was cut back to adjust for technical difficulties, projected cost growth, and funding constraints. Funding for fiscal years 1984 through 1988 totaled \$49.5 million.

The contractor expects to complete the Zenith Star beam control system by November 1992, based on the information learned from the brassboard system, according to an SDIO program official.

Primary Mirror

The program to produce a mirror for low-power ground experiments was completed about a year and a half behind the schedule in SDIO's 1984 Plan due to quality control problems and the breakage of a mirror segment. In 1987 the program produced the large primary mirror, which is to be modified for use on the Zenith Star space experiment. The mirror consists of seven segments that can be moved to shape the beam to the required quality needed to focus it on the target. (See fig. 2.3.)

Figure 2.3: Illustration of the Primary Mirror



SDIO officials said that the mirror requires modifications to operate with the high-powered laser device and to operate in space. SDIO does not plan to test the mirror with the high-powered laser on the ground before the space test; such a test did not fit Zenith Star's original, expedited schedule. Total program costs have been approximately \$40 million, including \$1 million to replace the broken mirror segment.

Acquisition, Tracking, and Pointing

An ATP subsystem enables the weapon system to find and track a target and to point a laser beam at a target. According to DOD officials, an ATP space experiment is essential to DOD's space-based laser research and demonstration. The date for an initial ATP space experiment has slipped from SDIO's original target of 1988 to September 1990.

Talon Gold, an ATP research program, was transferred to SDIO from DARPA. SDIO had initially planned two Talon Gold ATP space experiments—one to occur in fiscal year 1988 and a second, more advanced experiment in fiscal year 1990. These space experiments were canceled, and SDIO began two other space experiments, named Starlab and the Agile Control Experiment. Starlab is currently planned to be launched on the space shuttle in September 1990. The Agile Control Experiment was later canceled, and most of its objectives will be accomplished by the Zenith Star space experiment's forward spacecraft.

Space-Based Chemical Laser Given Earlier Role in Phased Deployment Plans

SDIO officials said that the priorities placed on research in SBCLs and ground-based free-electron lasers for a far-term role remain unchanged, and that both of the lasers and neutral particle beam weapons are candidates for a role in the late follow-on phase of the ballistic missile defense system's deployment. Officials said that (1) a possible early follow-on role for SBCL has been added to the program in connection with plans for phased deployment and (2) the SBCL program has not been emphasized to the detriment of other laser technologies. To support the SBCL's potential early follow-on role, SDIO proposed testing a laser in space 4 years earlier than originally planned; however, as of March 1989, the launch date for the Zenith Star test had slipped from the proposed accelerated 1990 launch date back to the mid-1990s.

Early Follow-On Role for SBCL Under Phased Deployment

SDIO's 1984 Directed Energy Weapon Program Plan was geared to supporting a 1990 decision on the feasibility of directed energy weapons for a late follow-on role against advanced Soviet ballistic missile threats. However, SDIO's planning in 1986 and 1987 for the phased deployment of a Strategic Defense System led to the proposal of an early follow-on role for an SBCL effective against near-term threats (see fig. 3.1).

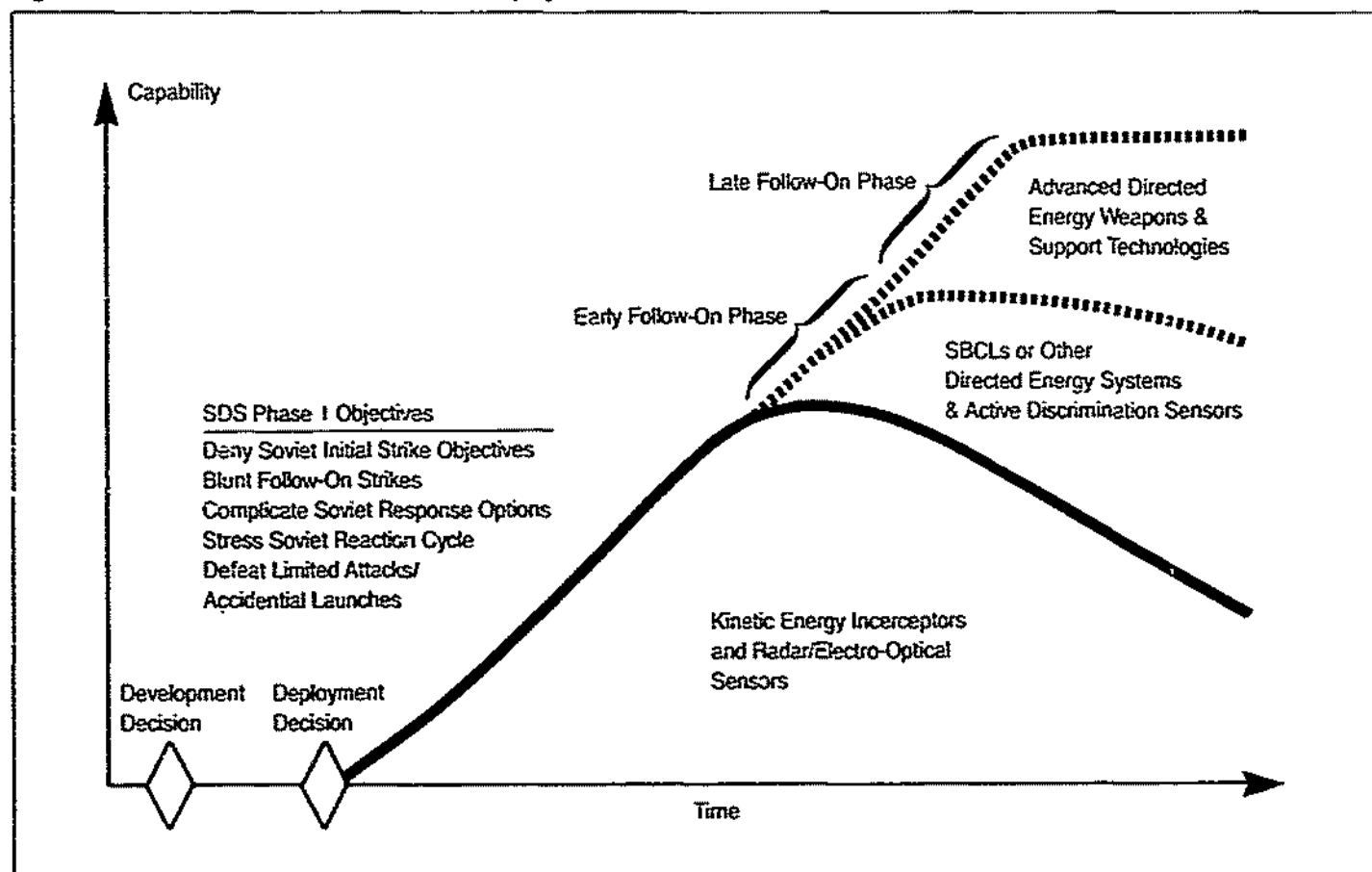
SBCL technology was the only directed energy technology SDIO considered mature enough to support the early follow-on role. The Zenith Star program was begun primarily to demonstrate SBCL's readiness to fulfill this new role. The role would be to destroy ballistic missile boosters and post-boost vehicles and to discriminate decoys from warheads in the midcourse phase.

SDIO noted that the Zenith Star program added the option of demonstrating the SBCL in space to earlier ground integration and demonstration plans. SDIO said that ground integration and testing is an important part of the Zenith Star program and was included in the 1984 Plan. SDIO also noted that Zenith Star's ATP experiments are essential to ground-based free-electron laser research, and the collection of optical signatures from space can benefit other future weapons and sensors.

Reason for the SBCL's Early Role

In developing phased deployment plans, SDIO's Director said that SDIO needed to demonstrate a capability to deal with responsive threats, or countermeasures, that the Soviets were likely to take in response to a phase I deployment of U.S. space-based interceptors. SDIO concluded that a directed energy weapon may be needed to counter possible Soviet responses to a phase I deployment. Only SBCL technology was judged

Figure 3.1: Possible Role of SBCL in Phased Deployment



mature enough to demonstrate a directed energy weapon in time for the originally proposed decision timetable for phase I.

SDIO's Director said that his strategy was to use the Zenith Star experiment to demonstrate to the Soviets that the United States had the potential to block certain responses they might readily take to our phase I deployment. SDIO hopes to deter the Soviets from building and deploying options they may have to counter a phase I deployment. If the Soviets were deterred, the United States might not need to invest in deploying SBCL weapons.

SDIO noted that this strategy, which it calls "branching and blocking," is central to the research, development, and deployment philosophy of the Strategic Defense System. The idea is to develop several technology alternatives (branches) that provide options for the United States and

are visible to the Soviets. The Soviets may thereby be persuaded to forego responses that can be "blocked" by U.S. options.

Early Role Tied Zenith Star's Schedule to the First Phase of Deployment

The 1984 Directed Energy Weapon Program Plan outlined plans to demonstrate SBCL technologies prior to a decision in 1990 on whether to do an integrated space demonstration of an SBCL. SDIO projected that such a space demonstration could occur in 1994.

To enable SDIO to demonstrate SBCL's potential new role against near-term threats, SDIO, in 1987, advanced the launch date for the first SBCL space experiment by about 4 years to 1990. This new schedule was intended to support the strategy of either deterring Soviet responses to phase I deployment or being ready to deploy an SBCL if the Soviets deployed responsive threats.

However, as of March 1989, SDIO officials had slipped Zenith Star's launch date from 1990 back to the mid-1990s for several reasons. One reason, according to program officials, was a lack of funds. Other reasons were that (1) the ABM Treaty compliance review process and national policy deliberations had taken about a year longer than SDIO originally anticipated and (2) ground demonstration of the Alpha laser had slipped.

Funding and Priority

We analyzed changes in SDIO's funding plans that supported the initiation of the Zenith Star space experiment in 1987. We also examined funding changes for the ground-based free-electron laser experiment to see whether compensating funding reductions had been made. We reviewed (1) SDIO's 5-year budget projections issued during 1985 and 1986 and (2) SDIO's annual budget requests and appropriations for fiscal years 1987, 1988, and 1989.

SDIO's 5-Year Budget Projections

In May 1985 SDIO's fiscal year 1987 Program Objective Memorandum for fiscal years 1987 through 1991 showed no funding for an SBCL space experiment until fiscal year 1991, when SDIO would decide whether to proceed with the experiment. The memorandum provided initial funding of \$100 million for fiscal year 1991.

In May 1986 SDIO's Program Objective Memorandum for fiscal years 1988 through 1992 funded the ground-based free-electron laser technology integration experiment, but it funded only a small planning effort

for a space-based laser concept as an alternative, in case the primary ground-based laser candidate did not measure up to expectations. The memorandum said that the SBCL technology integration experiment would either be pursued, maintained in a state of readiness as a hedge, or abandoned, depending on the outcome of research in the overall SDI Program.

SDIO's Annual Budget Requests and Appropriations

For fiscal year 1988, SDIO did not request any funding for an SBCL space experiment, but it subsequently allocated \$21 million for the experiment. For its initial fiscal year 1989 budget request submitted to the Congress in early 1987, SDIO also did not request any funding, but in a revised budget submitted to the Congress in early 1988, SDIO requested \$180 million.

For the ground-based free-electron laser experiment, SDIO initially requested \$158 million for fiscal year 1988. It subsequently allocated \$129 million of its appropriation, a reduction of \$29 million.¹ For its initial fiscal year 1989 request, SDIO asked the Congress for \$201.5 million but reduced the amount to \$198 million in its revised request, a reduction of \$3.5 million.

On the basis of our analysis of initial funding for fiscal years 1988 and 1989, we estimate that no more than \$32.5 million could have been transferred from the ground-based laser experiment to the SBCL experiment. The remaining funds would have had to come from other SDIO projects.

Although in 1987 SDIO had placed a higher priority on the Zenith Star space experiment by advancing its launch date from 1994 to 1990, SDIO subsequently moved the launch date back to the mid-1990s due to funding limitations.

Role Unchanged for Far Term

Although SDIO has added a role for SBCL as an early follow-on to phase I, the role and priority of the SBCL have not changed for far-term missions, according to SDIO officials. They stated that SBCLs, as well as ground-based free-electron lasers, are still being researched to determine which laser, or what combination of weapons, would be most effective for far-term missions. The SDIO Director stated that neither ground-based free-

¹SDIO subsequently reprogrammed an additional \$12 million for the ground-based laser experiment—increasing the funding for fiscal year 1988 from \$129 million to \$141 million.

electron laser research nor SBCL research has demonstrated that obstacles to a cost-effective weapon design have been overcome.

Compliance of the Zenith Star Experiment With the ABM Treaty

In September 1988 DOD's Compliance Review Group certified that the proposed Zenith Star test design complies with the traditional, or restrictive, interpretation of the ABM Treaty supported by the Senate Committee on Foreign Relations and the Senate and House Committees on Armed Services. Initial Zenith Star design feasibility studies were not required to explore Treaty-compliant designs. Such studies are permitted under the 1972 ABM Treaty, even if the studies propose tests that would not comply with the Treaty. For the second phase of Zenith Star studies, which began in August 1987, SDIO directed the contractors to comply with the ABM Treaty and to use specific design features that SDIO officials believed would comply with the Treaty's restrictive interpretation.

In early 1987, both the Congress and the President had asked DOD to explore options for testing under the broad Treaty interpretation. A concept for a Laser Integrated Space Experiment (LISE) was devised to satisfy the requests by the Congress and the President. If the administration and the Congress had agreed to use the broad interpretation, Zenith Star design studies could have been oriented to implement the LISE option.

Treaty Interpretation Debate

In late 1985 the administration presented a new interpretation of the 1972 ABM Treaty, which the Senate Committee on Foreign Relations has called a reinterpretation from the traditional, or restrictive, U.S. interpretation. The essence of the administration's broad interpretation, as it applies to Zenith Star, is that it grants wide latitude in testing weapon prototypes, such as lasers, that are based on other physical principles than those used in ABM systems at the time of the Treaty, even if such prototypes have a mobile basing mode, as in space.

In contrast, the restrictive interpretation requires all tests, including those of weapon concepts based on new technologies, to be scrutinized under a restrictive set of interpretive principles and rules. Broadly speaking, under the restrictive interpretation, Zenith Star cannot have the capability of substituting for an ABM radar or an ABM interceptor and cannot be tested in an ABM mode, according to DOD.

DOD stated that its approach to ABM Treaty compliance for the SDI test program, as explained to key congressional leaders in late 1987, involves (1) identifying the best technical program for SDI, (2) presenting the program to the Congress for its consideration, (3) if that program raises issues regarding ABM Treaty interpretation, addressing those with

the Congress, considering the specifics of the proposed program, and (4) undertaking to keep the Congress fully informed as to the plans for tests that would raise such questions. President Reagan stated that he considered the broad interpretation to be fully justified.

Congressional deliberations on the interpretation of the Treaty resulted in a 1987 resolution by the Senate Committee on Foreign Relations supporting the traditional, or restrictive, interpretation. In addition, funding restrictions by the Senate and House Committees on Armed Services for fiscal years 1988 and 1989 limited SDI test expenditures to tests that DOD judges comply with the restrictive interpretation.

Zenith Star Experiment

Initial contractor design studies for the Zenith Star, from January to June 1987, were not restricted to designing experiments that complied with the ABM Treaty. Near the end of the initial feasibility studies in early June 1987, SDIO tasked the contractors to include Treaty-compliant design options in their proposals for the next study phase. For the second study phase, begun in August 1987, SDIO directed the contractors to design an experiment that would comply with the ABM Treaty. Proposed designs were submitted to DOD's Compliance Review Group beginning in June 1987.

Initial Experiment Design Not Required to Comply With Treaty

In a December 1986 assessment of Zenith Star proposals, SDIO concluded that, although feasibility studies posed no ABM Treaty issues, the proposed space experiment did raise fundamental interpretation issues. An initial assessment by the SDIO General Counsel's representative concluded that the early Zenith Star proposals should be permissible under the broad interpretation of the Treaty endorsed by President Reagan, but might be questionable using the restrictive interpretation. The General Counsel's representative stated that the questionable items were subsequently altered or deleted so that the experiment would comply with the restrictive interpretation.

SDIO's January 1987 "Statement of Work" for the initial Zenith Star feasibility study contract did not contain a requirement that the experiment design comply with the ABM Treaty. In addition, the contract called for experiment features that might be questionable under the Treaty's restrictive interpretation. SDIO officials stated that it is their practice not to constrain initial design feasibility studies because it is important to learn what the technology can do. Also, the Treaty permits such studies. In early June 1987, SDIO redirected the contractors to include experiment

design options that, in SDIO's opinion, would comply with the restrictive Treaty interpretation. The contractors were instructed to include such options in addenda to the final reports for this initial study phase.

Contracts for the Second Phase of the Design Studies Required Compliance With the Treaty

In the June 1987 Statement of Work for the second phase of the Zenith Star design studies, SDIO inserted specific experiment features that it believed would make the experiment compliant with the restrictive Treaty interpretation. The primary features inserted to ensure compliance had to do with special design of test targets and with restricting the target acquisition and tracking capabilities of the test hardware. Interpretation of the ABM Treaty is stated in the contracts as a government responsibility.

DOD's Compliance Review of the Zenith Star

DOD's Under Secretary of Defense for Acquisition is responsible for the compliance review. The analytic work of DOD's compliance review is the responsibility of the Compliance Review Group, chaired by the Assistant Deputy Director for Strategy, Arms Control, and Compliance, in the Office of the Deputy Director for Strategic and Theater Nuclear Forces. Other members are from the Office of the General Counsel, the Under Secretary of Defense for Policy, and the Joint Chiefs of Staff. SDIO's Office of the General Counsel participates to provide input and to observe. The Compliance Review Group used consultants to provide expertise on the Treaty's interpretation and negotiation record and on the technical aspects of lasers and ATP technology.

DOD's compliance review process has existed since 1972, following the Strategic Arms Limitation Talks I agreements. The process is documented in SDIO's 1985 Report to the Congress on the Strategic Defense Initiative and in hearings by the Subcommittee on Strategic and Nuclear Deterrence, Senate Committee on Armed Services, on April 1, 1987.

DOD's Compliance Review Group reviewed the Zenith Star designs from June 1987 through September 1988 to determine whether the Zenith Star experiment would comply with the ABM Treaty. In September 1988 the Under Secretary of Defense for Acquisition said that the Zenith Star did comply with the Treaty's restrictive interpretation.

DOD's compliance review on the Zenith Star focused on the capabilities of the high-powered laser, the fire control for the laser, the ATP science module, and on the type of targets used. The general Treaty compliance criteria that the Group assessed these features against were (1) that the

test hardware should not be capable of being a substitute for an ABM system or component and should not be a prototype of a system or component and (2) that the test would not be done "in an ABM mode" against a target in a strategic ballistic missile's trajectory.

The extended time the Group took to reach a compliance decision on Zenith Star was due to several factors, according to participants we spoke with and records we reviewed. There was considerable learning involved for participants because this was their first review of a high-powered directed energy experiment in space. The Review Group exercised extra caution because of the national policy issues involved in placing such a laser in space, such as its potential antisatellite capabilities. In addition, considerable delay and inefficiency were introduced into the process because of the participants' other responsibilities, including high-priority events such as the Intermediate Range Nuclear Forces agreements.

LISE Option for a Space-Based Chemical Laser Experiment

In early 1987 both the Congress and President Reagan had asked DOD to explore options for testing under the broad Treaty interpretation. The concept for such an experiment, called LISE, was included in a report to the President in April 1987 and in a report to the Congress in May 1987.² Senator Johnston and former Senator Proxmire asked us to provide information on the relationship between this proposal and the Zenith Star experiment. They noted articles in the press suggesting that the LISE proposal and Zenith Star were related and that the administration intended to violate the ABM Treaty's restrictive interpretation.

President Reagan had told DOD to submit a plan for restructuring the SDI Program under the broad interpretation of the Treaty. The report was to include a description of the first tests that would require a broad interpretation of the Treaty and the dates of these tests. According to an SDIO official, the LISE description was prepared in response to the President's request. The report was not released to the Congress.

The Congress had also asked DOD during fiscal year 1987 authorization proceedings to report on the effects of the broad Treaty interpretation on the SDI program. The report to the Congress included LISE as one of four tests that SDIO could pursue if permitted to use the broad interpretation. DOD officials said that the LISE description was basically the same

²A Report to Congress on the Anti-Ballistic Missile Treaty, May 19, 1987. An unclassified version was issued on September 21, 1987.

experiment described in the earlier report to President Reagan. The description of the test that was included in each of the reports was prepared by SDIO's Office of Directed Energy. SDIO officials said that if the broad Treaty interpretation had been adopted, Zenith Star design work could have been oriented to develop the LSE concept.

Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



DEPARTMENT OF DEFENSE
STRATEGIC DEFENSE INITIATIVE ORGANIZATION
WASHINGTON, DC 20301-7100

February 10, 1989

T/DE

Mr. Frank C. Conahan
Assistant Comptroller General for
National Security and International Affairs
U. S. General Accounting Office
Washington, DC 20548

Dear Mr. Conahan:

This is the Department of Defense response to the General Accounting Office (GAO) draft report entitled: "STRATEGIC DEFENSE INITIATIVE PROGRAM: Zenith Star Space-Based Chemical Laser Experiment," dated December 22, 1988, OSD Case 7866 (GAO Code 392382). The DoD generally concurs with the GAO findings. Clarifications and additional information are provided, however, to preclude any misinterpretation of the findings.

Detailed DoD comments on the specific report findings are provided in the enclosure. The Department appreciates the opportunity to comment on the draft report.

Sincerely,

A handwritten signature in dark ink, appearing to read "Eugene Fox".
EUGENE FOX
Major General, USA
Acting Deputy Director

Enclosure:
As Stated

GAO DRAFT REPORT - DATED DECEMBER 22, 1988
(GAO CODE 392383) OSD CASE 7866

"STRATEGIC DEFENSE INITIATIVE PROGRAM:
Zenith Star Space-Based Chemical Laser Experiment"

DEPARTMENT OF DEFENSE COMMENTS

* * * * *

FINDINGS

- o FINDING A: Phased Deployment. The GAO reported that, in 1987, the Strategic Defense Initiative (SDI) Program underwent a major change when the Department of Defense (DoD) approved a phased deployment approach for a ballistic missile defense system. The GAO found that phased deployment of the Strategic Defense System involves deploying the full population protection defensive system proposed by President Reagan in successive phases over a period of time. The GAO observed this approach anticipates that defense elements would be deployed when they can perform cost-effectively against the threat anticipated for their deployment period. The GAO noted it is the view of the Joint Chiefs of Staff that a "thoroughly effective defense" could only be achieved in steps. The GAO reported that the plans provide for the initial deployment of a Phase I system (early 1990s), to be followed by several follow-on deployment phases, as the Soviet threat evolves. For the purposes of this review, the GAO divided the follow-on phases into an early follow-on phase (mid to late 1990s) and a late follow-on phase (after the year 2000).

The GAO observed that the addition of laser weapons to cope with changes in the Soviet ballistic missile threat is a major feature of the follow-on deployment phases. The GAO reported that the SDIO is developing space-based chemical lasers (SBCL) and ground-based free-electron lasers for deployment during the follow-on phases. The GAO found that the SBCLs are the leading candidate for deployment during the early follow-on phase because they are the most mature laser technology. The GAO observed that they would be used to destroy Soviet missiles during the boost phase, supplementing the space-based interceptor rockets deployed during Phase I.

The GAO further reported that, in 1984, the SDIO developed a Directed Energy Program Plan, which defined the research and ground demonstrations to enable a decision to be made in 1990 on whether to begin developing a space experiment (that would be launched in 1994). The GAO observed, however, that to demonstrate the SBCL technology in a time frame consistent with phased deployment planning, in January 1987 the SDIO created the Zenith Star Program. The GAO found that

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the program was begun primarily to demonstrate the operation of an SBCL in space. The GAO noted that the Zenith Star spacecraft will be comprised of a laser and a science module and, after experiments with the laser, the science module will continue with acquisition, tracking and pointing experiments. (pp. 2-3, pp. 8-11/GAO Draft Report)

DoD Position: Concur. The GAO reported, "...Phase I would occur in the early 1990s; an early follow-on would occur in the mid- to late 1990s; and an advanced follow-on deployment, or far-term phase, would occur after the year 2000." At this time, the SDIO projects that Phase I capability will be in place in the late 1990s. Therefore, an early follow-on might occur in the early 2000s.

The DoD also submits the following to clarify and amplify several other points in this finding.

- The DoD position on the criteria for deployment is that the resulting system be survivable, cost-effective and militarily effective, rather than the GAO statement that "defense elements would be deployed when they can perform cost-effectively against the threat anticipated for their deployment period."
- As the GAO observed, the SBCL is indeed the most mature of the high-energy laser technologies and would augment the boost, post-boost and midcourse discrimination capabilities of the Phase I deployment. The DoD recognizes that this survey is directed to high-energy lasers, but wishes to add for completeness that the neutral particle beam is also a viable candidate for deployment during the follow-on phases. The GAO summary of the 1984 Directed Energy Plan is correct.
- The space-based chemical laser element is at the stage of development where integration of component technologies is a required next step. The Zenith Star program, which has been structured to include several years of integration and test activities on the ground, accomplishes this in a logical manner. Ground integration for space-based chemical laser technologies was included in the 1984 plan. What has been added is the option to go to space.
- The observation that Zenith Star was initiated to support a phased deployment, primarily to demonstrate the operation of a chemical laser in space, while correct, does not convey the overall technical value of the Zenith Star program to the Directed Energy Directorate, and to the Strategic Defense System. Therefore, the DoD points out that: (1) The Zenith Star experiments resolve critical space beam control and ATP (acquisition, tracking and pointing) issues for

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See comment 1.

space-based and ground-based high-energy laser concepts. These experiments are therefore as essential for the development of the ground-based free electron laser (GBFEL) concept as they are for the space-based chemical laser; (2) The information to be obtained from detailed design, subscale risk reduction and ground integration and testing is essential for supporting a timely and confident decision on whether to proceed with the next development phase; and, (3) the data to be obtained on the optical signatures of space objects and backgrounds will contribute significantly to all directed energy concepts and to the data base for future advanced weapons and sensors.

- o FINDING B: Status of Technologies. The GAO reported that, since 1984, the SBCL technology programs have fallen one to two years behind the 1984 schedule. The GAO found that some of the planned research work has been eliminated or significantly cut back. The GAO further found that, while the laser has been built, it has not yet produced a laser beam. The GAO observed that the laser program has experienced delays, modifications, and cost overruns. (The GAO noted that the ground test has been delayed from the end of 1987 to early 1989, and that the cost estimate has increased from \$149 million to \$186 million.) The GAO also found that, instead of producing the originally planned full-scale beam control device, the SDIO built a laboratory bench system (called a brassboard) for testing the electronic and optical components, controls, and software. The GAO noted that the high-power beam control system for Zenith Star has yet to be built. The GAO also observed that, while the primary mirror program is also about one year behind the original schedule, the program has completed final acceptance test and is within its original cost estimates (approximately \$40 million). Finally, the GAO found that the original acquisition, tracking and pointing (ATP) space experiment has slipped and is now scheduled for shuttle launch as STARLAB in September 1990. (pp. 2-4, pp. 12-15/GAO Draft Report)

Now on pp. 2-3, 12-16.

DoD Position: Concur. The following information is provided to place the GAO observations in perspective.

- The original ATP experiment (Talon Gold) has not slipped - it was cancelled. An entirely new program (Starlab) with a new set of objectives was created.
- As the GAO points out, several of the SBCL² technology development activities have indeed fallen behind the 1984 schedule, and some of the planned research work has been cut back. This was due in part to unanticipated technical problems. The DoD wishes to point out, however, that the scope and rate of progress envisioned in the 1984 Directed Energy Program Plan was predicated on budget requests which, for the most part, were

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substantially cut back in the appropriation process. Funding constraints, as well as unanticipated technical difficulties, have had a major impact on space-based chemical laser technology progress, and account for much of the slips, cut-backs and modifications referred to in the report.

- It is correct that the Zenith Star high-power beam control system has yet to be built. The program has only recently entered the detailed design phase. Fabrication of the beam control system is not yet under contract. Based upon present budgets, its completion is planned for FY1992.

FINDING C: Priorities. The GAO reported that, according to SDIO officials, research priorities remain unchanged for the SBCLs and the ground-based free electron lasers for deployment during the late follow-on phase. The GAO noted that, in early 1987, an early follow-on deployment role for the SBCLs was added to the program, but SDIO officials maintained this additional program has not been emphasized to the detriment of other laser technologies. The GAO noted the Director, SDIO, stated neither the ground-based nor space-based laser research has yet demonstrated that obstacles to a cost-effective weapon design have been overcome.

The GAO further reported that the SDIO Director said that in developing phased deployment plans, the SDIO needed to demonstrate a capability to deal with responsive threats, or countermeasures, that the Soviets were likely to take in response to a Phase I deployment of U.S. space-based interceptors. The GAO noted that SDIO concluded that a directed energy weapon may be needed to counter possible Soviet responses, and that only SBCL technology was mature enough to demonstrate a directed energy weapon consistent with the original proposed decision timetable for Phase I.

The GAO noted that, in addition, the SDIO Director said that it was his strategy to use the Zenith Star experiment to demonstrate to the Soviets that the United States had the potential to block certain responses they might readily take to our Phase I deployment. The GAO noted that the hope was to deter the Soviets from building and deploying options they may have to counter a Phase I deployment and if the Soviets were deterred, the United States might not need to invest in deploying space-based chemical laser weapons.

The GAO found that, accordingly, the SDIO proposed testing a laser in space four years earlier than the originally planned 1994 date (when the SBCL research was supporting only a late follow-on deployment role). The GAO also found that, as of November 1988, the launch date for the Zenith Star test has slipped from the proposed date of 1990, to the mid-1990s. The GAO reported that the slip occurred because the Defense

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Now on pp. 3, 4, 17-21.

Acquisition Board directed the SDIO to reduce the cost of the SDI program to fit within the Five Year Defense Program funding profile. (p. 3, pp. 16-19/GAO Draft Report)

DoD Position: Concur. The strategy of "branching and blocking" described by the Director is central to the Strategic Defense System research, development and deployment philosophy. The concept is to develop several "branches" (technology alternatives) which would provide real options for the U.S., and be visible to the Soviet Union. By doing this, the Soviets may be persuaded to forego responses (offensive deployments) which can be "blocked" by these options.

See pp. 19-20.

- o FINDING D: FUNDING. The GAO concludes that the FY1988 allocation for the ground-based free electron laser experiment was \$129,000,000, and its revised request for FY1989 is \$198,000,000. Further, the GAO states that DoD's revised request for FY1989 is \$198,000,000.

DoD Position: Partially Concur. The FY1988 allocation was correct at the time it was obtained. However, at the end of FY1988, \$141,000,000 had been provided, not \$129,000,000.

The funds cited by the GAO reflect only those in the SDIO work package D076, which is supporting development of the free-electron laser and beam control system at White Sands. Work package D076 is only one of several work packages supporting the development of technology for the free electron laser element of the Strategic Defense System. The total amount of support provided by the SDIO for FEL technology development (Project #20) in FY1988 was \$172,055,000. Further, an additional \$73,252,000 dollars was provided in FY1988 for ATP activities, which are uniquely required for the development of the free-electron laser weapons element. The total support for the free-electron laser concept in FY1988 was therefore \$245,307,000. The total FY1989 allocation, on a similar basis, is \$240,057,000. The source of the above financial data is the SDIO Financial And Management Information Summary (FAMIS), dated December 27, 1989.

- o FINDING E: Compliance of Zenith Star Experiment With ABM Treaty. The GAO reported that, in late 1985, the Reagan Administration presented a new interpretation of the 1972 Antiballistic Missile (ABM) Treaty, which the Congress has called a re-interpretation from the traditional, or restrictive, U.S. interpretation that the Congress endorsed. The GAO found that the restrictive interpretation requires all tests, including those of weapon concepts based on new technologies, to be scrutinized under a restrictive set of interpretive principles and rules. (These principles and rules are to assure that the test hardware cannot be judged capable of substituting for an ABM system or component, is not a prototype of a system or component, and is not being

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"tested in an ABM mode" against targets prohibited by the treaty.) The GAO reported that, although the President has stated he considers the broad interpretation to be legally correct, the official Administration policy continues to be that testing will comply with the restrictive interpretation.

The GAO reported that SDIO planning and contractor design studies for Zenith Star, during the period from October 1986 through May 1987 were not restricted to comply with the ABM Treaty (The GAO observed, however, that such studies are permitted under the Treaty.) The GAO noted that, according to SDIO officials, unrestricted feasibility studies are done to understand the capabilities of the technology. The GAO found, however, that in May 1987, design studies were redirected toward compliance with the restrictive treaty interpretation prior to submitting preliminary designs for formal treaty compliance review by the DoD.

Finally, the GAO reported that the proposed designs were submitted to the DoD Compliance Review Group, beginning in June 1987, and that in September 1988, the DoD determined that the Zenith Star experiment complied with the restrictive interpretation of the ABM Treaty. (The GAO noted that the Laser Integrated Space Experiment (LISE) also had been explored as one of four tests that could have been pursued under the broad interpretation.) (p. 5, pp. 20-24/GAO Draft Report)

DoD Position: Concur. The language within Paragraph 1 of Finding E should, however, read:

The GAO reported that, in late 1985, the Reagan Administration presented an interpretation of the 1972 Antiballistic Missile (ABM) Treaty, set forth by the State Department's Legal Advisor and termed "fully justified" by President Reagan. This was different from the traditional, or restrictive, interpretation that some members of Congress believe that the Congress had endorsed. The GAO found that the restrictive interpretation requires all tests, including those of weapon concepts based on new technologies, to be evaluated under a restrictive set of interpretive principles and rules. Broadly speaking, under the restrictive interpretation, space-based devices such as lasers based on other physical principles cannot have the capability of substituting for an ABM radar or an ABM interceptor and cannot be tested in an ABM mode. Despite the above, the Reagan Administration policy continued to be that testing comply with the restrictive interpretation.

In addition, the DoD restates the approach to compliance as explained to key Congressional leaders in late 1987. The approach involves: identifying the best technical program for SDI; presenting the program to Congress for its consideration; if that program raises an issue regarding

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Now on pp. 4-5, 22-26.

ABM Treaty interpretation, addressing those with Congress, considering the specifics of the proposed program; and undertaking to keep Congress fully informed as to the plans for tests that would raise such questions.

The DoD emphasizes that design studies per se "were not redirected to comply," as GAO states, but that design studies "were directed, in June of 1987, toward experiment design options which would comply" with the restrictive interpretation. As the GAO notes, studies and concepts are not restricted by the 1972 ABM Treaty.

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The following are GAO's comments on the Department of Defense's letter dated February 10, 1989.

GAO Comments

1. This material was deleted from the final report.
2. The funding section was revised to clarify that we focused on the \$129 million figure to cover the time period when SDIO was proposing to accelerate an SBCL space experiment by initiating the Zenith Star program. The final \$141 million figure for the ground-based free-electron laser would be comparable in time to a final SBCL funding of \$34.4 million; this figure represents a later slippage of Zenith Star's proposed schedule priority.

In its comments on a draft of this report, DOD expressed concern that our limiting our analysis of funding to the ground-based free-electron laser experiment at White Sands Proving Ground did not give the total picture of funding for this technology. We also did not add the cost of ongoing SBCL research described in chapter 2 to the Zenith Star experiment figures discussed here. Our purpose was to look at funding directly related to the two experiments.

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